AIRS DATA ASSIMILATION WORKSHOP

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CLEAR COLUMN RADIANCE ERRORS

CLEAR COLUMN RADIANCES $\hat{R}_i$ ARE THE RADIANCES WHICH WOULD HAVE BEEN OBSERVED IF NO CLOUDS WERE PRESENT

$\hat{R}_i$ ARE RECONSTRUCTED FROM OBSERVED RADIANCES IN ADJACENT FIELDS OF VIEW

AIRS TEAM GEOPHYSICAL PARAMETER RETRIEVALS USE $\hat{R}_i$

RADIANCE ASSIMILATION CAN USE $\hat{R}_i$ AS WELL

$\hat{R}_i$ IS AN AIRS TEAM PRODUCT, ALONG WITH ITS UNCERTAINTY $\square\hat{R}_i$

WILL SHOW ERRORS FOR

- "CLEAR" CASES
- "NEAR CLEAR" CASES
- EASY CLOUD CONDITIONS
- ALL CLOUD CONDITIONS

ALL RESULTS SHOWN ARE FOR JANUARY 2001 VERSION OF THE DECEMBER 15, 2000 DATA SET AND RUN AT GSFC

CLOUD CLEARING

$$R_{I,J} = \left[1 - \sum_K \alpha_{JK}\right] R_{I,CLR} + \sum_K \alpha_{JK} R_{I,CLD\,K}$$

CHANNEL I, FIELD OF VIEW J, CLOUD FRACTION α_{JK}

WE USE OBSERVATIONS IN 9 FIELDS OF VIEW TO OBTAIN $\hat{R}_I$

$$\hat{R}_I = \overline{R}_I + \sum_{J=1}^{9} \eta_J \left(\overline{R}_I - R_{I,J}\right) = \overline{R}_i + \sum_{J=1}^{9} \eta_J \Delta R_{I,J}$$

$\overline{R}_I$ = AVERAGE RADIANCE IN 9 SPOTS

UNCONSTRAINED SOLUTION

$$\eta = \left(\Delta R' N^{-1} \Delta R\right)^{-1} \Delta R' N^{-1} \Delta R_{CLR}$$

N = CHANNEL NOISE COVARIANCE MATRIX

$$\Delta R_{CLR} = R_{CLR,I} - \overline{R}_I$$

$R_{CLR,I}$ IS THE ESTIMATED CLEAR COLUMN RADIANCE COMPUTED FROM A STATE THAT AGREES WITH AMSU RADIANCES

DETERMINATION OF NUMBER OF CLOUD FORMATIONS

DIAGONALIZE $\Delta R \cdot N^{-1} \cdot \Delta R$ BY THE TRANSFORMATION U

EQUIVALENT TO SELECTION OF NEW FIELDS OF VIEW $\Delta R^{T} = U \Delta R$

DETERMINE ONE CLOUD FORMATION FOR EACH SIGNIFICANT EIGENVALUE λ_K

FOR kmax SIGNIFICANT EIGENVALUES

$$\hat{R}_I = \bar{R}_I + \sum_{K=1}^{k\,max} \alpha_K \, \Delta R^{T}_{I,K}$$

WHERE

$$\alpha_K = \lambda_K^{-1} \left(\Delta R^{T} \cdot N^{-1} \, \Delta R_{CLR} \right)_{K,1}$$

IF NO SIGNIFICANT EIGENVALUES EXIST

$\hat{R}_I = \bar{R}_I$ $\quad\quad$ $\delta \hat{R}_I = 1/3\, NE\Delta N_I$ FOR ALL CHANNELS

ABOVE IS ALSO TRUE FOR CHANNELS THAT DO NOT SEE CLOUDS (CASE DEPENDENT)

$\delta \hat{R}_I$ TELLS WHEN NO CLOUD CORRECTION HAS BEEN MADE

EFFECTS OF CLOUDS ON CHANNEL NOISE

$$\hat{R}_I = \overline{R}_i + \sum_{J=1}^{9} \eta_J \left(\overline{R}_I - R_{I,J} \right) \qquad \text{WHERE} \quad \eta = U\square$$

IF ALL η_J ARE PERFECT

$$NE\Delta N_I(\eta) = NE\Delta N_I \left[\sum_{J=1}^{9} \left(\frac{1}{9} \left(1 + \sum_{J=1}^{9} \eta_J \right) - \eta_J \right)^2 \right]^{1/2} = NE\Delta N_I \; A(\eta_J)$$

$A(\eta_J)$ IS CALLED THE NOISE AMPLIFICATION FACTOR

$A(\eta_J) = 1/3$ IF ALL $\eta_J = 0$

$A(\eta_J)$ CAN GET LARGE. WE CURRENTLY REJECT RETRIEVALS IF $A(\eta_J) > 3$

THE RADIANCE ERRORS ARE UNCORRELATED FROM CHANNEL TO CHANNEL

CHANNEL CORRELATED ERRORS

ERRORS IN η_J CONTRIBUTE TO CORRELATED ERRORS IN $\hat{R}_I$

CORRELATED ERRORS ARE MODELLED AND INCLUDED IN $\square\hat{R}_I$

"CLEAR" AND "NEAR CLEAR" CASES

"CLEAR"

1) WE LOOK AT EIGENVALUES OF $\Delta R' N^{-1} \Delta R$

CALL CASE CLOUDY IF $\lambda_{MAX} > \lambda_{THRESHOLD}$

$\lambda_{THRESHOLD}$ = 80 FOR OCEAN, AND 200 FOR LAND

ALLOWS FOR MORE SCENE VARIABILITY OVER LAND BECAUSE OF MORE SURFACE VARIABILITY

2) WE ALSO LOOK AT CORRECTION TO CLOUD CLEARED WINDOW RADIANCES

ΔBT = AVERAGE VALUE OF $\hat{\Theta}_I - \overline{\Theta}_I$ FOR CHANNELS BETWEEN 800 cm^{-1} AND 900 cm^{-1} WHERE Θ IS BRIGHTNESS TEMPERATURE

CALL CASE CLOUDY IF $|\Delta BT| > 0.1K$

IF NEITHER, CALL CASE "CLEAR"

"NEAR CLEAR"

CALL CASE "NEAR CLEAR" IF $|\Delta BT| < 1K$ REGARDLESS OF EIGENVALUES

EASY CLOUD CASES

CLOUD CASES ARE EASIER TO HANDLE IF ONLY ONE CLOUD FORMATION EXISTS

$$\hat{R}_I = \overline{R}_I + \sum_{K=1}^{k_{max}} \square_K \square R_{I,K}^T$$

HIGHER ORDER CLOUD FORMATIONS CONTRIBUTE $\sum_{K=2}^{k_{max}} \square_K \square R_{I,K}^T$ TO $\hat{R}_I$

WE SAY THE CLOUD CASE IS EASY IF HIGHER ORDER CLOUD FORMATIONS CONTRIBUTE LESS THAN 0.2K TO ΔBT

AND

$\Delta BT < 20$

CLEAR COLUMN BRIGHTNESS TEMPERATURE STATISTICS

THE FOLLOWING PLOTS SHOW MEAN AND RMS VALUES OF

THE DIFFERENCE BETWEEN THE ACTUAL CLEAR COLUMN BRIGHTNESS TEMPERATURE AND THE AVERAGE OBSERVED BRIGHTNESS TEMPERATURE IN THE SCENE (THE CLOUD CORRECTION NEEDED)

THE CLOUD CORRECTION MADE

THE DIFFERENCE BETWEEN THE CLOUD CORRECTION NEEDED AND THE CLOUD CORRECTION MADE

ALSO SHOWN ON RMS IS THE SINGLE SPOT CHANNEL NOISE

All results are based on Version 2.2.5.aa global simulation of AIRS radiances for 15 December 2000.

CLEAR COLUMN BRIGHTNESS TEMPERATURE ERRORS

CLEAR CASES

- BIASES
  - WORST BIASES OF CLEAR COLUMN RADIANCES IN WINDOWS □ 0.2K
  - 0.2K CORRECTION NEEDED, NO CORRECTION MADE ON AVERAGE
- RMS ERRORS
  - MOST SOUNDING CHANNELS HAVE LOWER ERRORS THAN SINGLE SPOT NOISE

NEARLY CLEAR CASES

- BIASES
  - WORST BIASES ARE ABOUT 0.3K IN WINDOWS
  - 0.4K CORRECTION NEEDED ON AVERAGE
- RMS ERRORS
  - MOST SOUNDING CHANNELS HAVE LOWER ERRORS THAN SINGLE SPOT NOISE

EASY CLOUD CASES

- BIASES
  - WORST BIASES ARE ABOUT 0.3K IN WINDOWS
  - 5K CORRECTION NEEDED ON AVERAGE

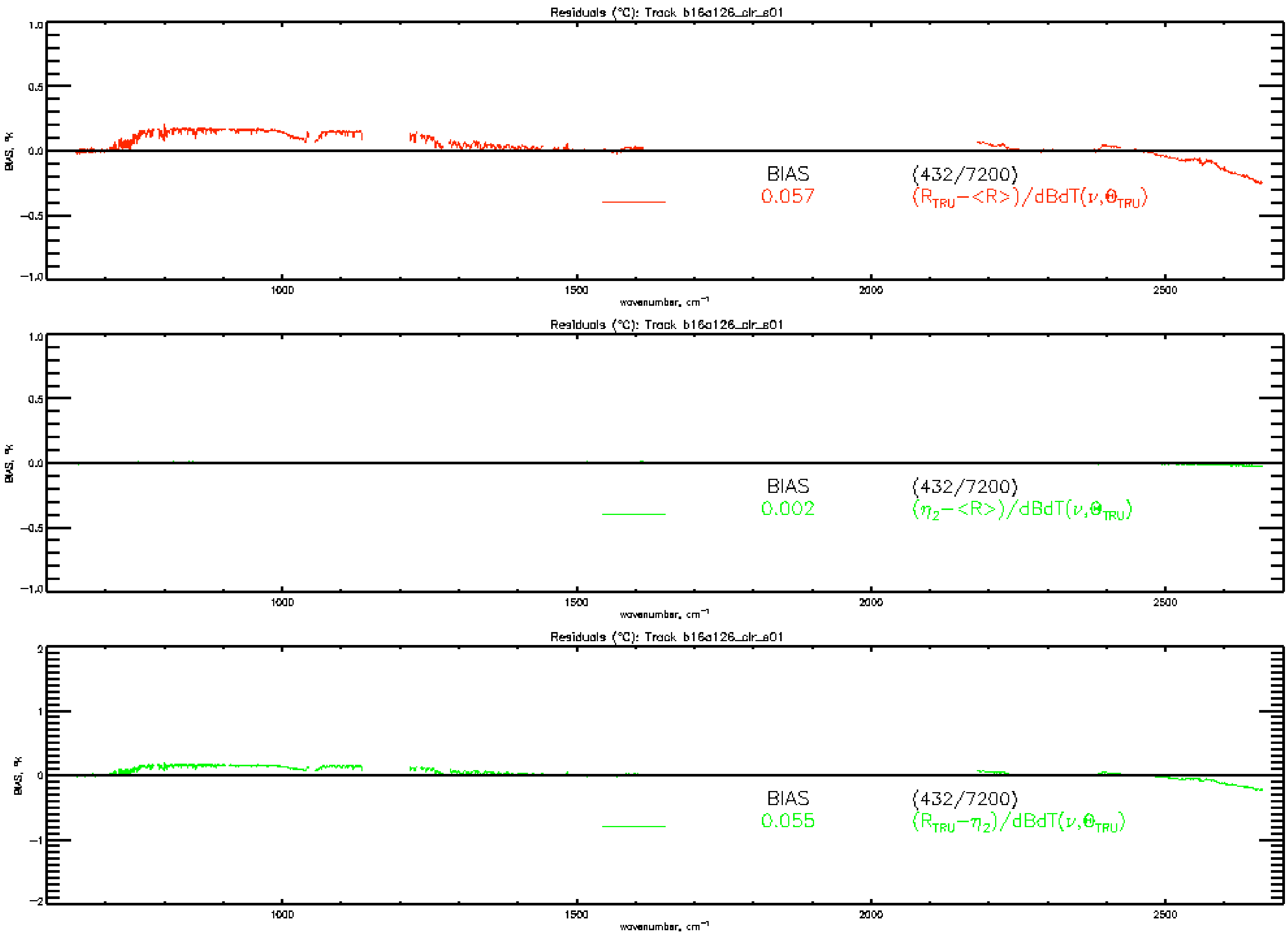
- RMS ERRORS
  - MOST TEMPERATURE SOUNDING CHANNELS HAVE LOWER OR SIMILAR ERRORS COMPARED TO SINGLE SPOT NOISE

ALL CASES

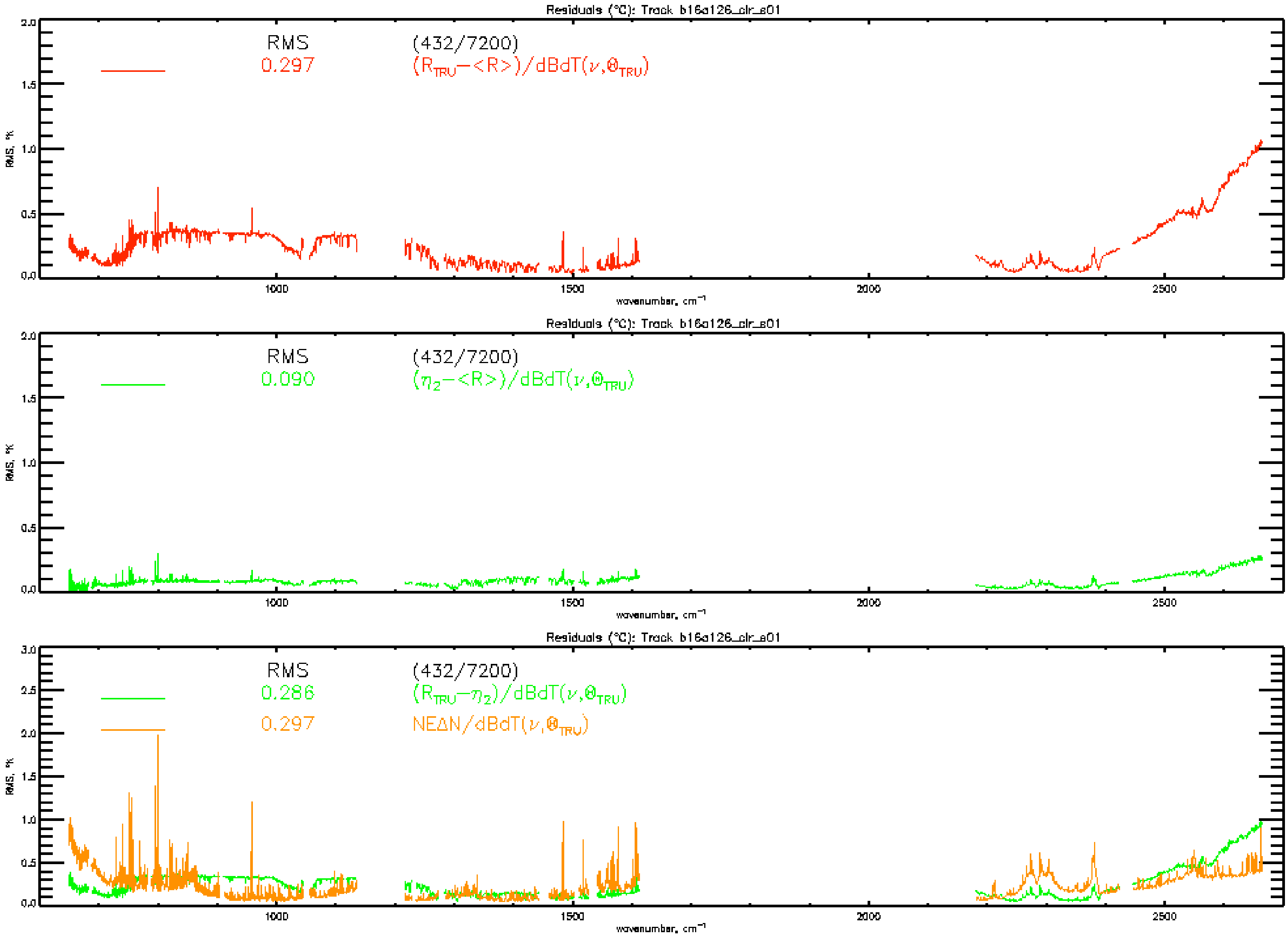
- BIASES
  - WORST BIASES ARE ABOUT 0.4K
  - 11K CORRECTION NEEDED ON AVERAGE

- RMS ERRORS
  - MOST TEMPERATURE SOUNDING CHANNELS HAVE ERRORS COMPARABLE OR SLIGHTLY WORSE THAN SINGLE SPOT NOISE

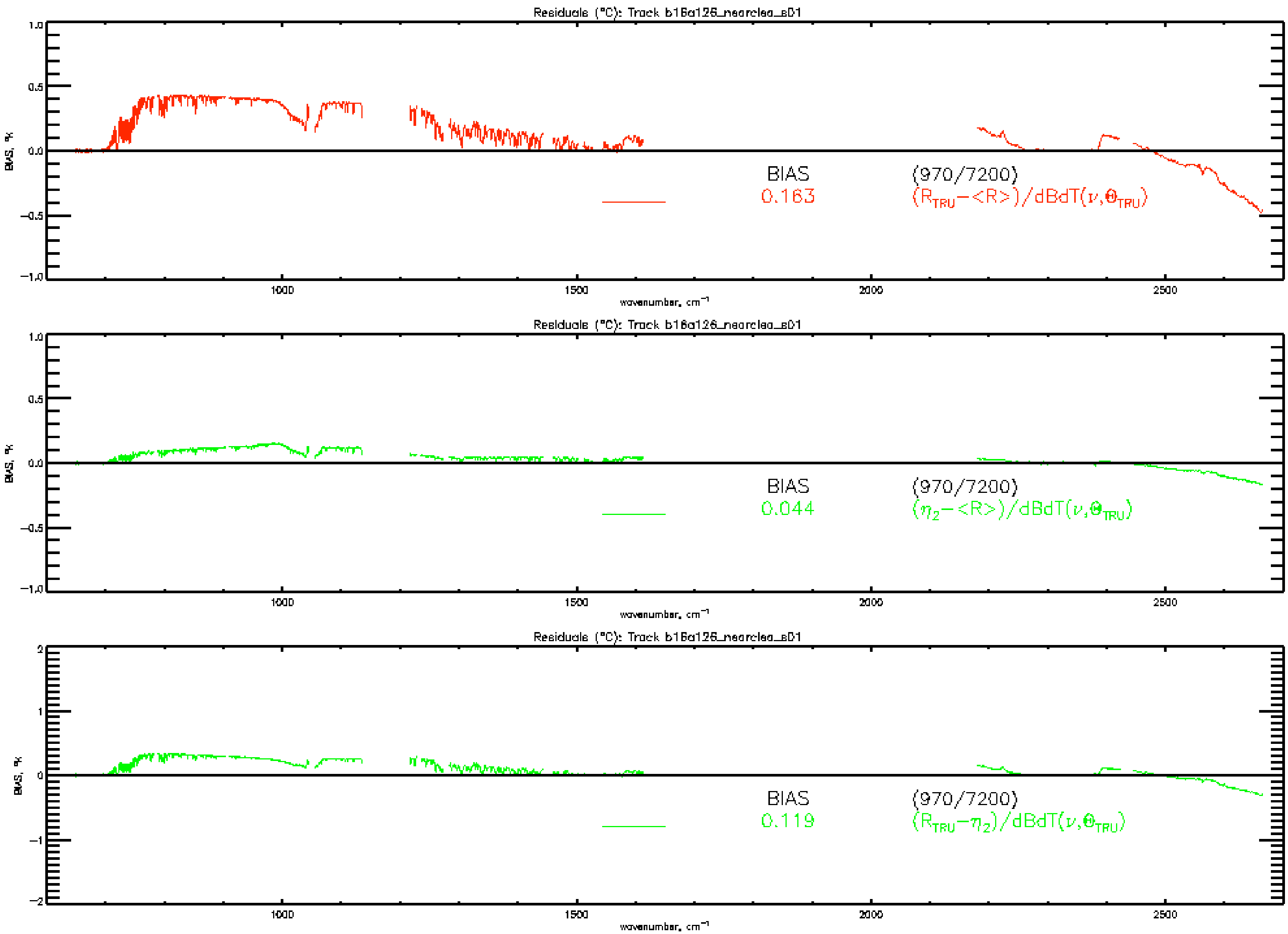
CLEAR CASES


Residuals (°C): Track b16a126_clr_s01
BIAS, %
1.0
0.5
0.0
−0.5
−1.0
1000
1500
2000
2500
wavenumber, cm⁻¹
BIAS
0.057
(432/7200)
(R_TRU−<R>)/dBdT(ν,Θ_TRU)
Residuals (°C): Track b16a126_clr_s01
BIAS, %
1.0
0.5
0.0
−0.5
−1.0
1000
1500
2000
2500
wavenumber, cm⁻¹
BIAS
0.002
(432/7200)
(η_2−<R>)/dBdT(ν,Θ_TRU)
Residuals (°C): Track b16a126_clr_s01
BIAS, %
2
1
0
−1
−2
1000
1500
2000
2500
wavenumber, cm⁻¹
BIAS
0.055
(432/7200)
(R_TRU−η_2)/dBdT(ν,Θ_TRU)

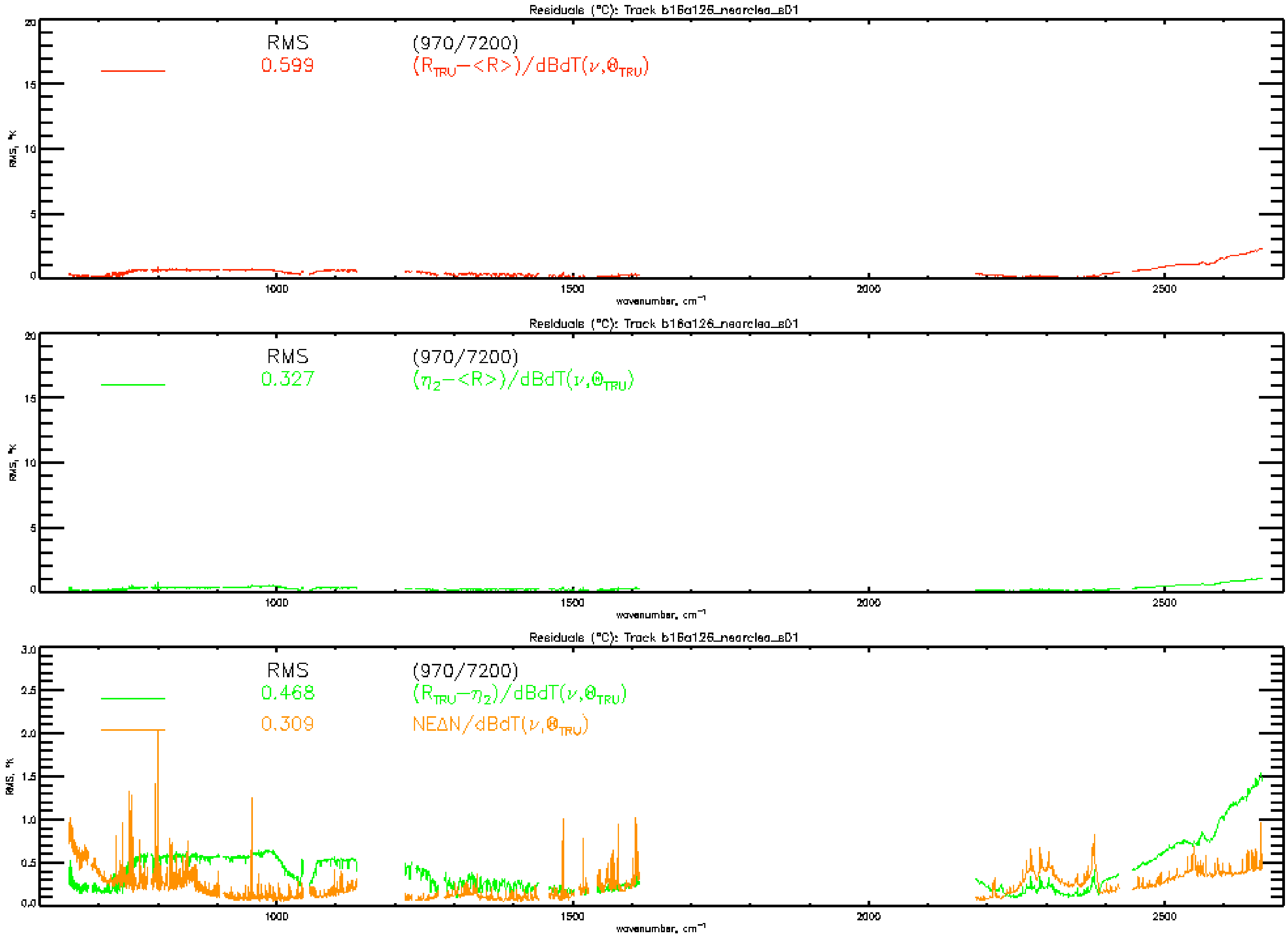
CLEAR CASES


Residuals (°C): Track b16a126_clr_s01
RMS
0.297
(432/7200)
(R_TRU−<R>)/dBdT(ν,Θ_TRU)
RMS, °K
wavenumber, cm⁻¹
Residuals (°C): Track b16a126_clr_s01
RMS
0.090
(432/7200)
(η₂−<R>)/dBdT(ν,Θ_TRU)
RMS, °K
wavenumber, cm⁻¹
Residuals (°C): Track b16a126_clr_s01
RMS
0.286
0.297
(432/7200)
(R_TRU−η₂)/dBdT(ν,Θ_TRU)
NEΔN/dBdT(ν,Θ_TRU)
RMS, °K
wavenumber, cm⁻¹

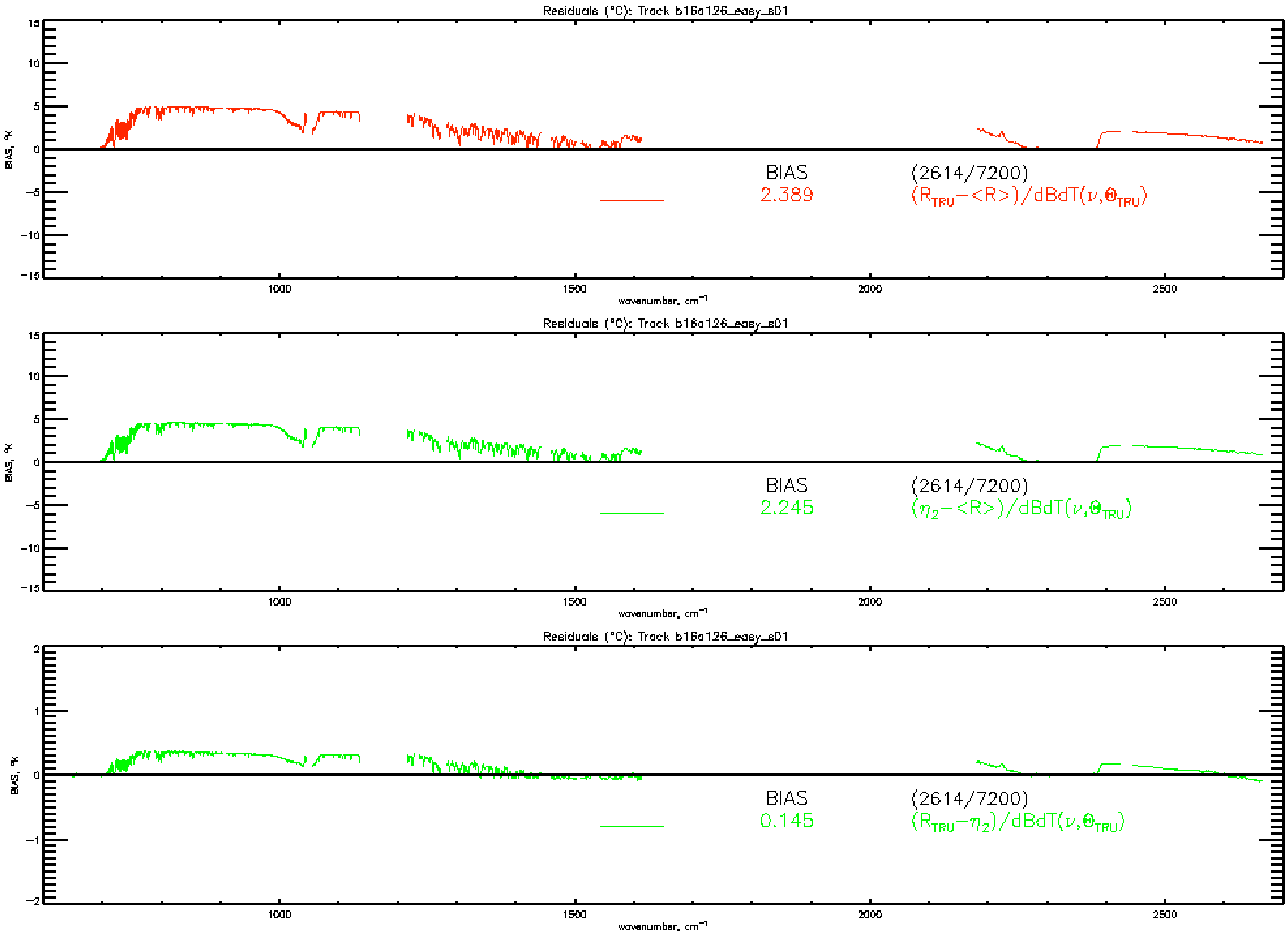
NEARLY CLEAR CASES



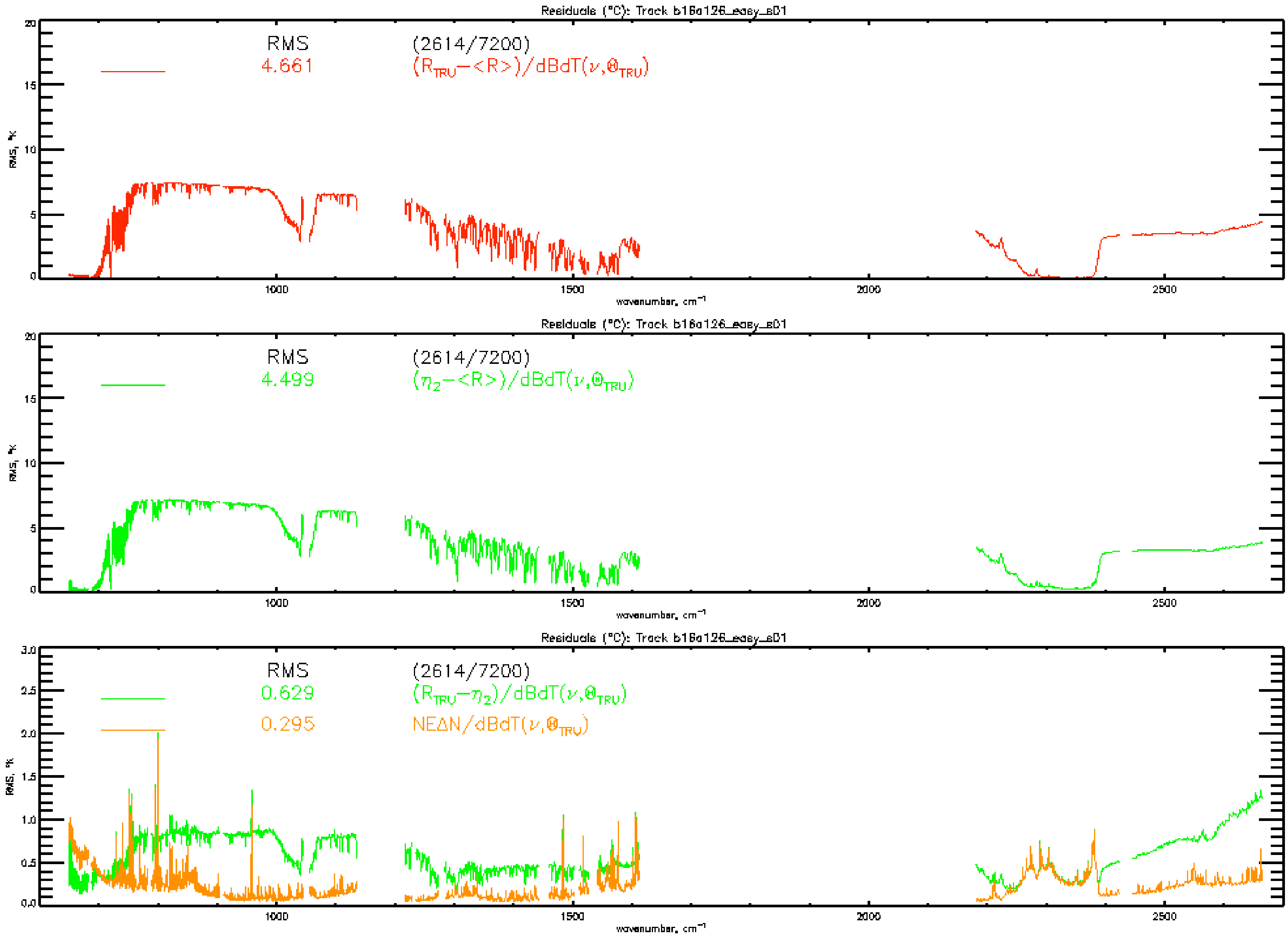
NEARLY CLEAR CASES



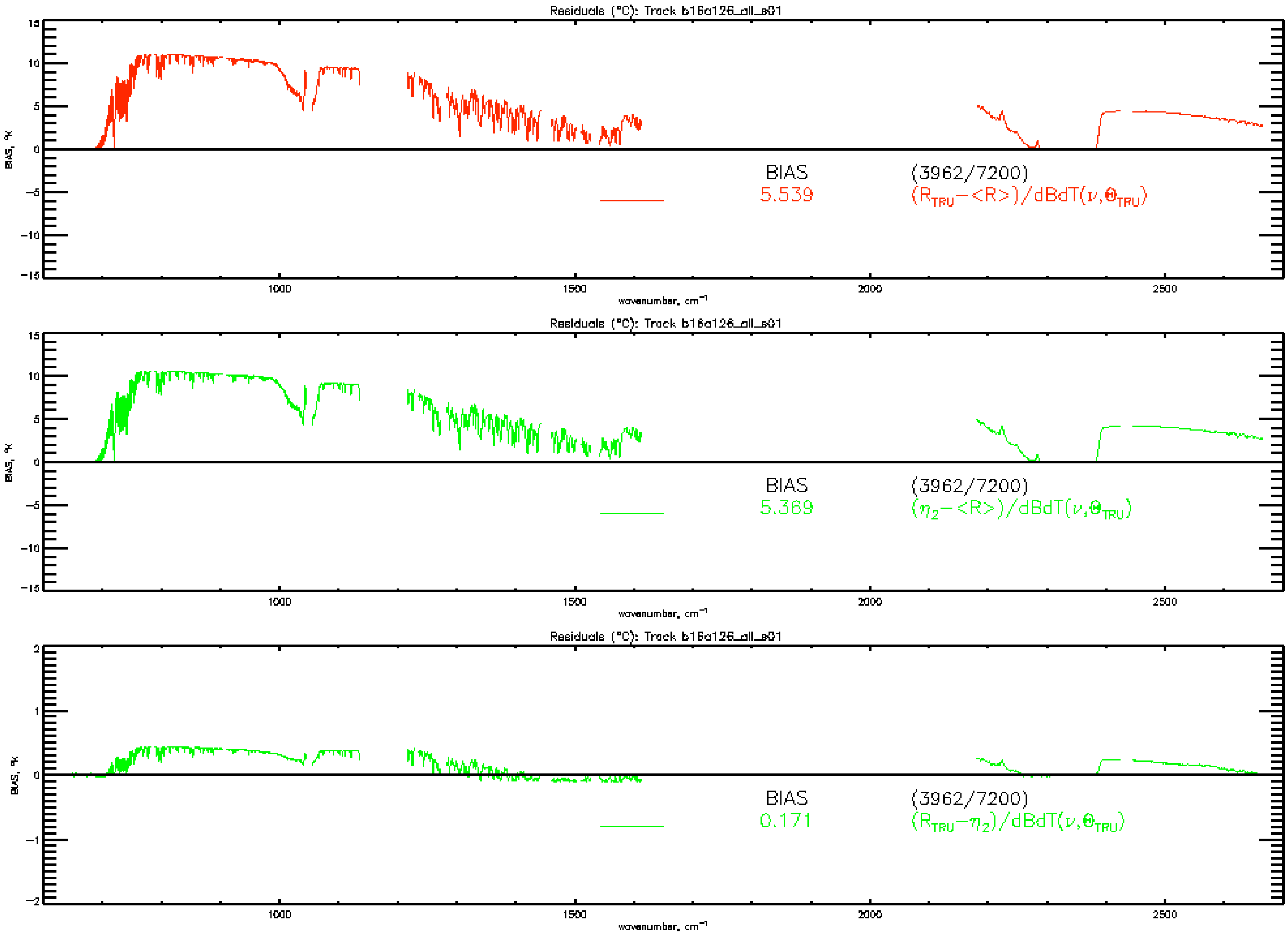
EASY CLOUD CASES



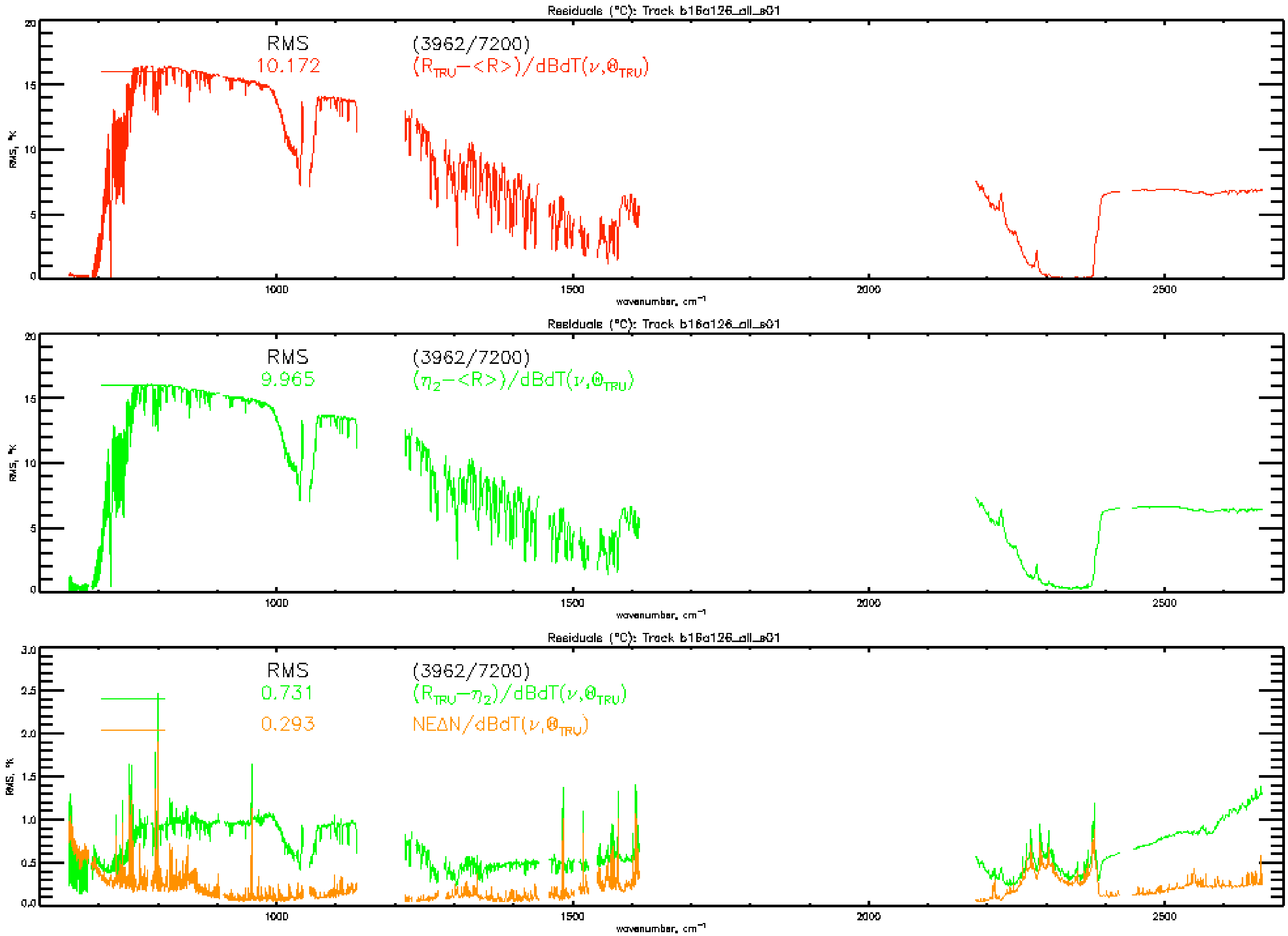
EASY CLOUD CASES



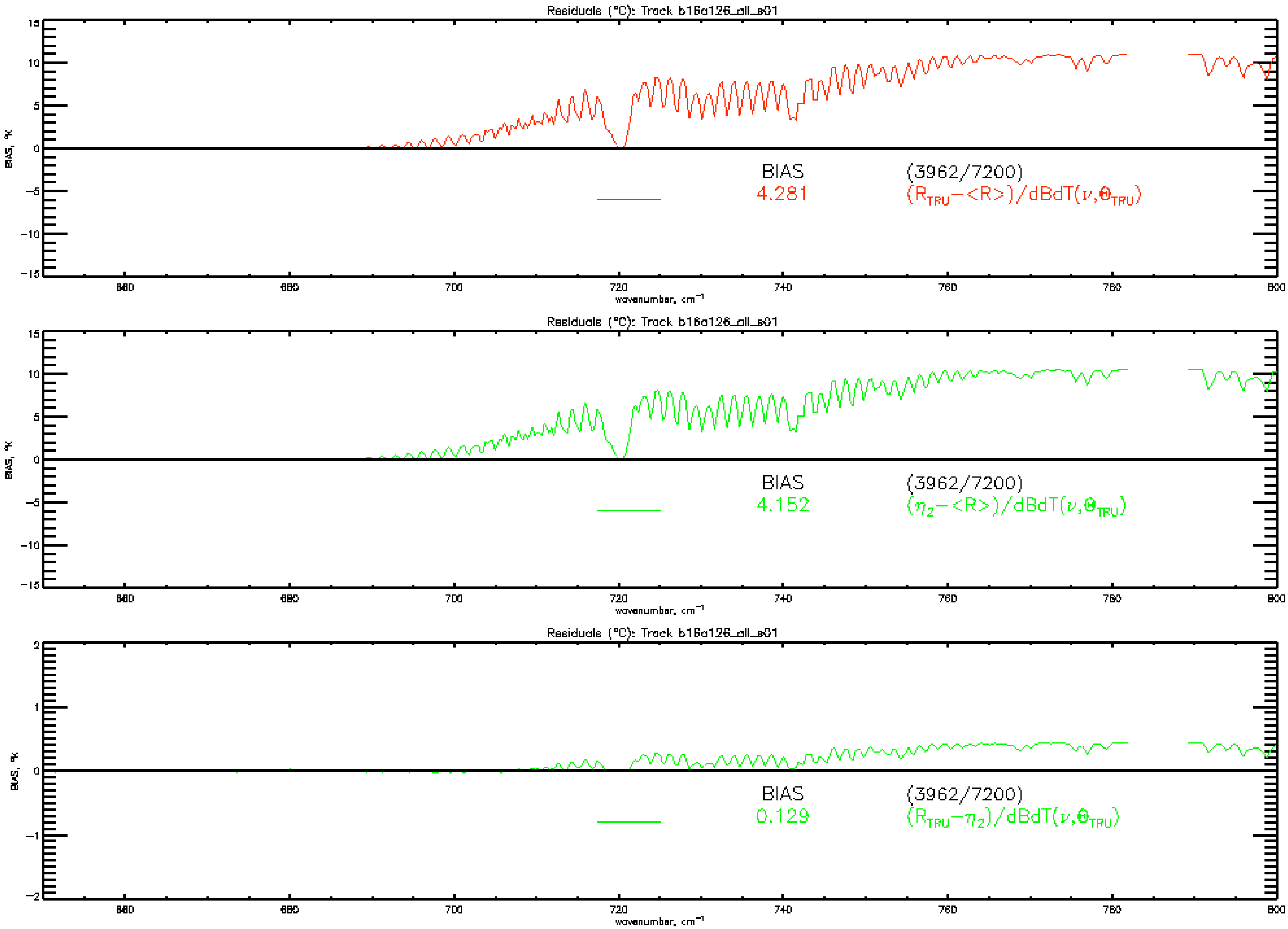
ALL ACCEPTED CASES



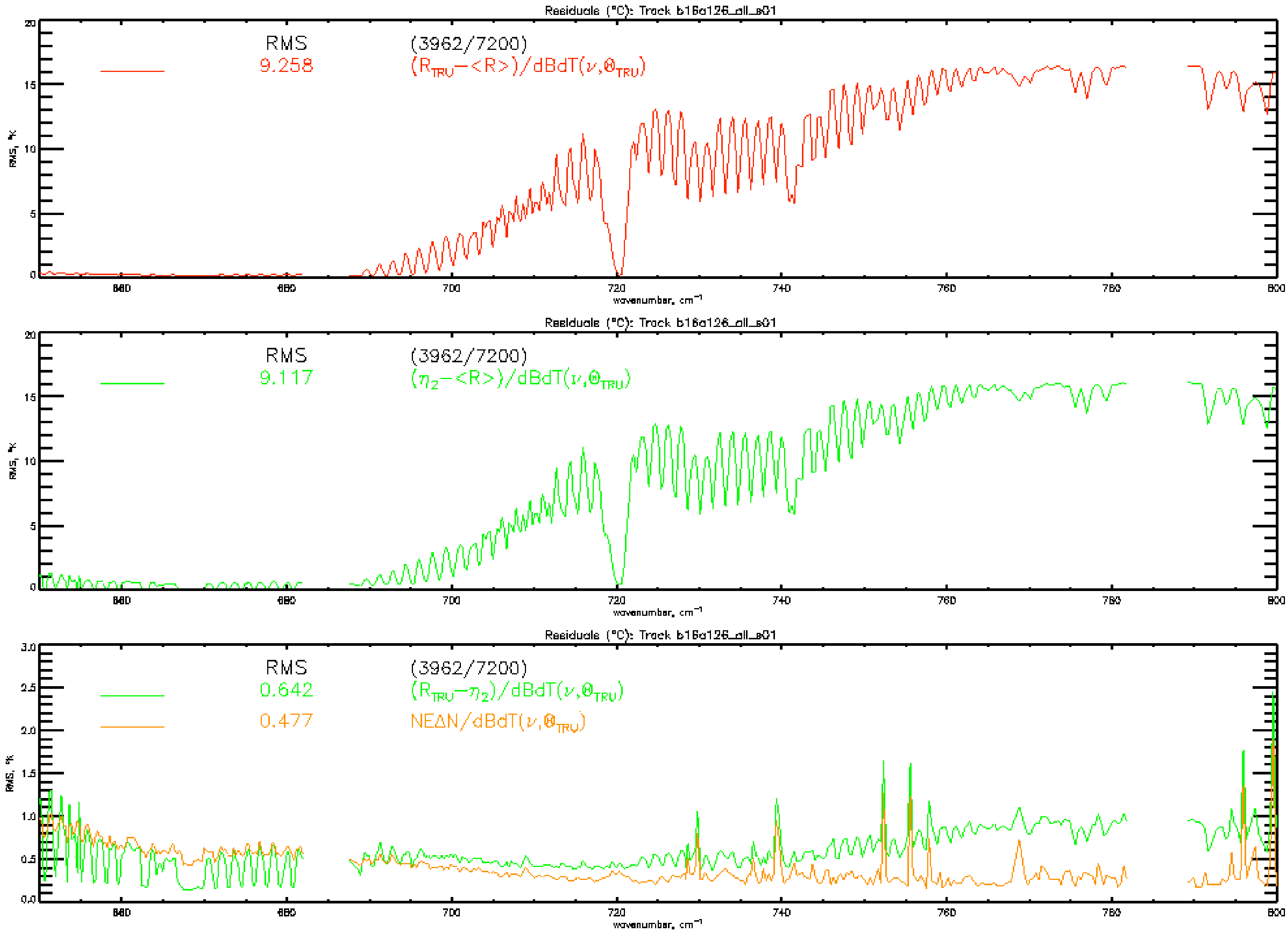
ALL ACCEPTED CASES

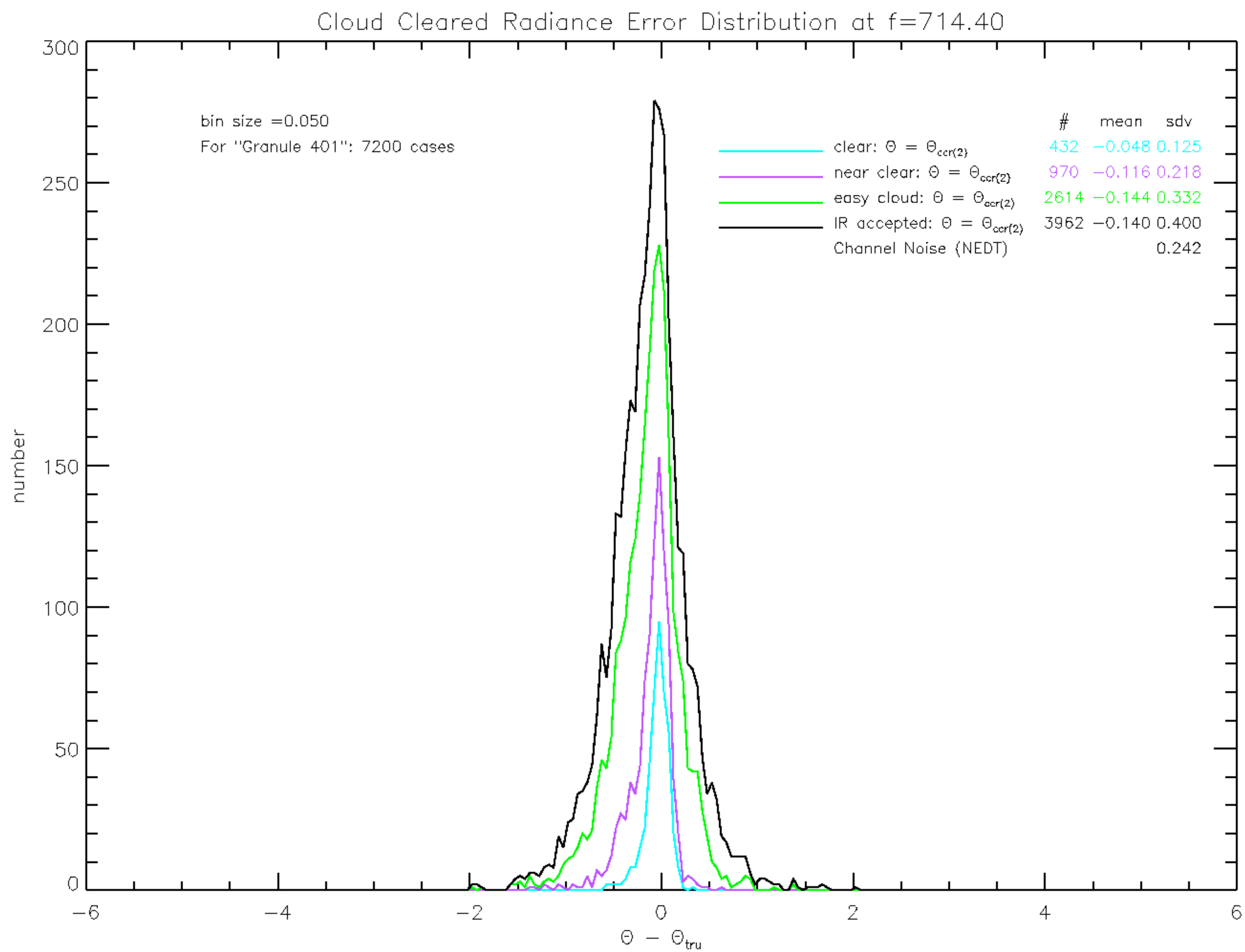


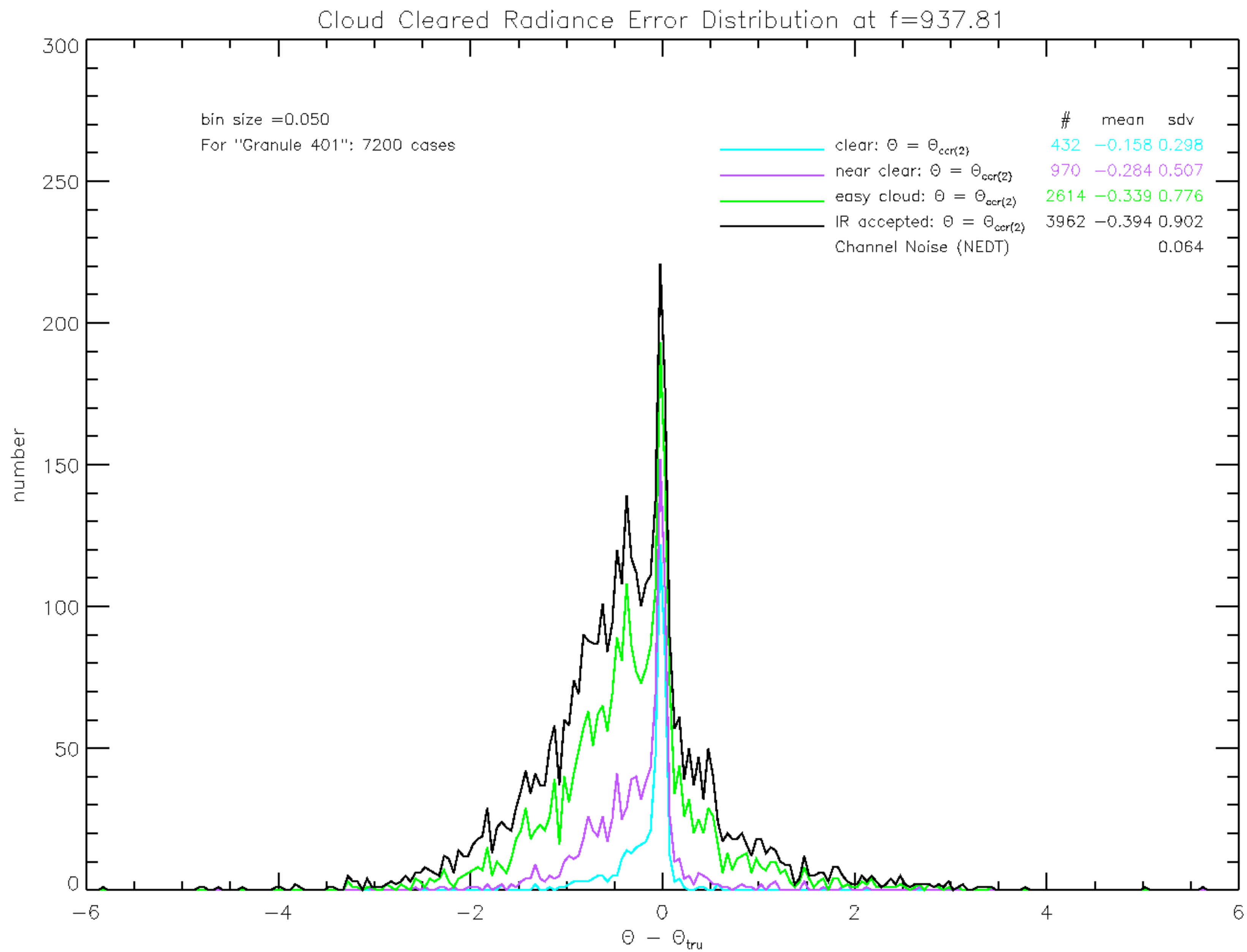
ALL ACCEPTED CASES



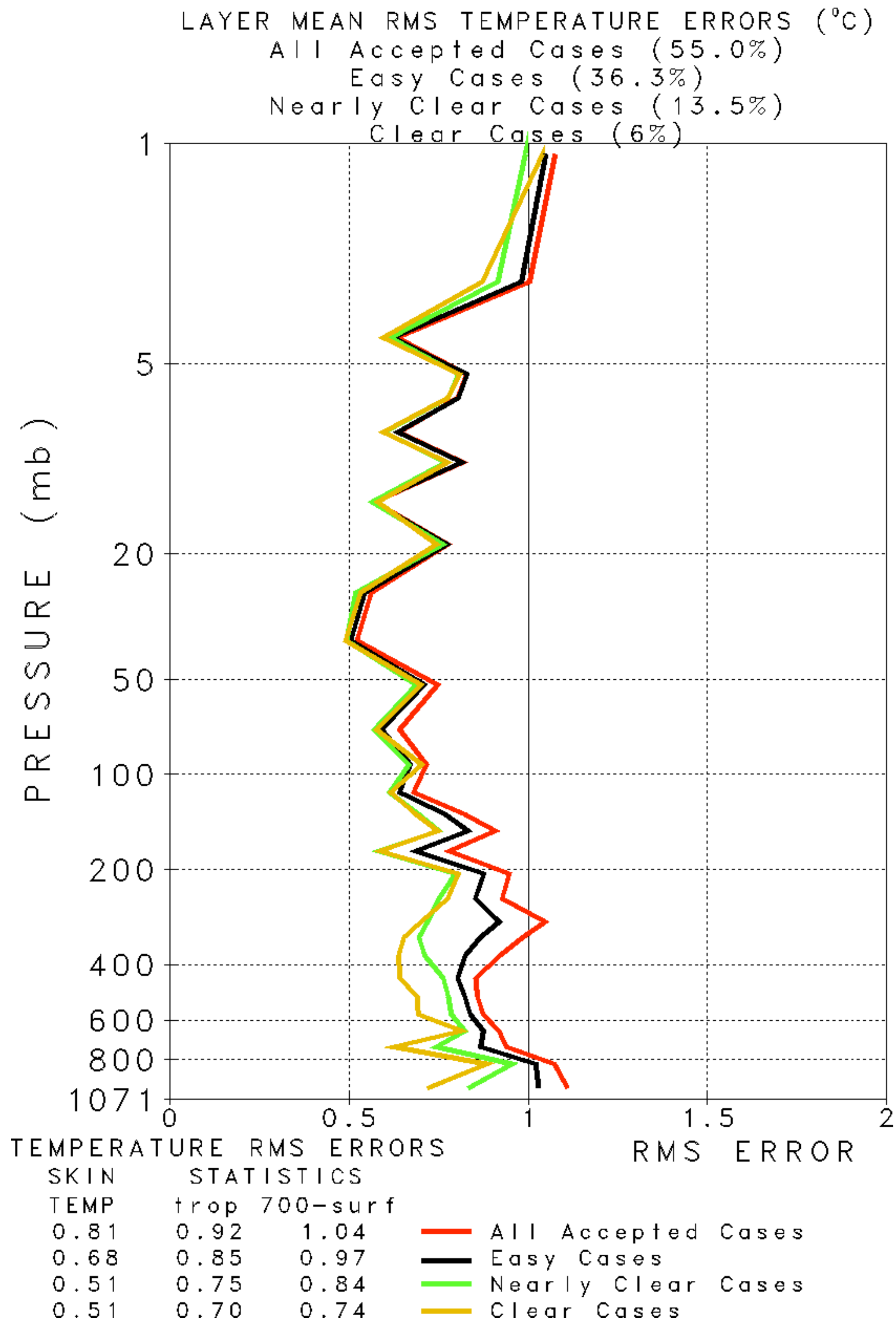
ALL ACCEPTED CASES

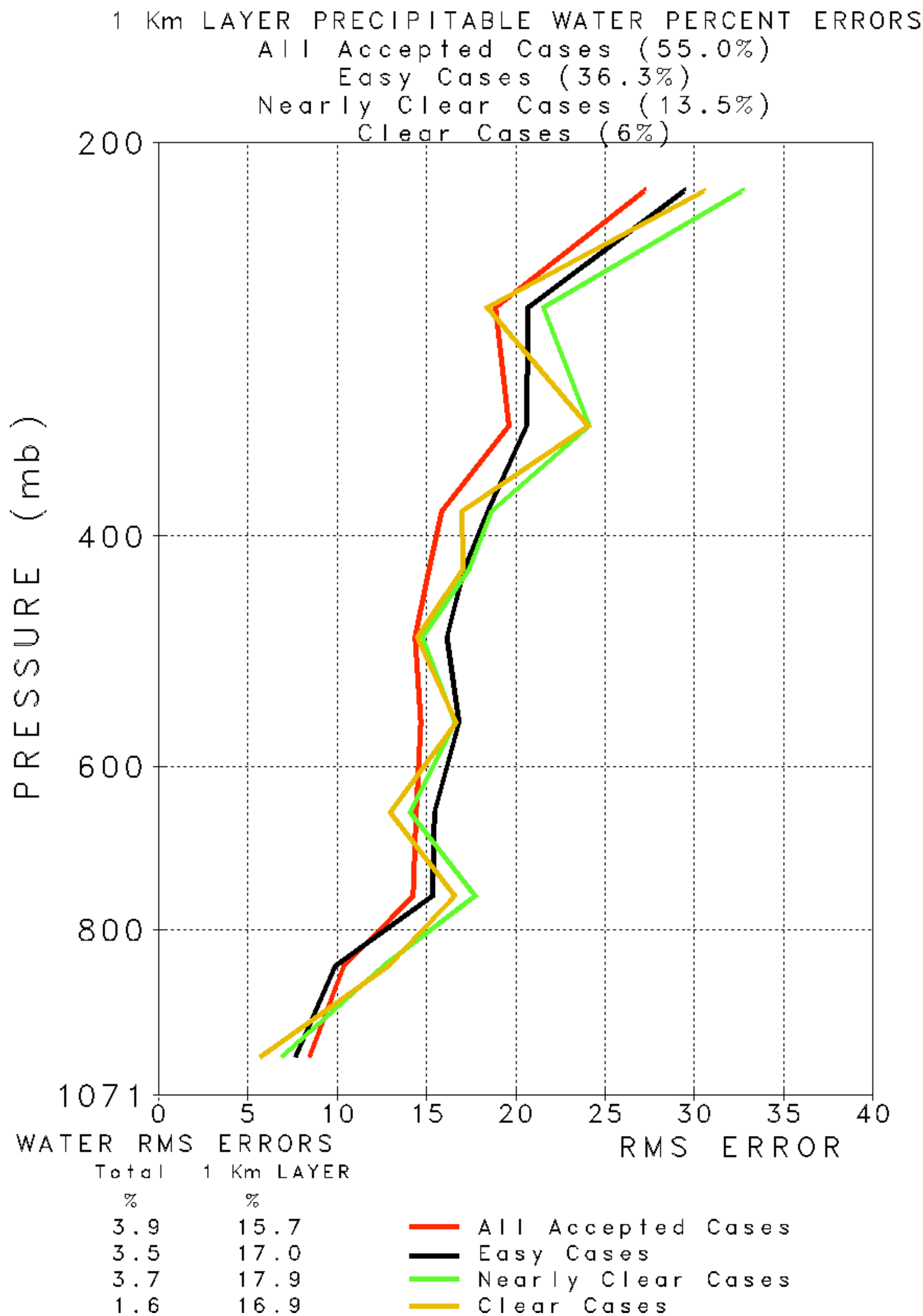



Cloud Cleared Radiance Error Distribution at f=714.40
bin size =0.050
For "Granule 401": 7200 cases
mean sdv
clear: Θ = Θccr(2) 432 −0.048 0.125
near clear: Θ = Θccr(2) 970 −0.116 0.218
easy cloud: Θ = Θccr(2) 2614 −0.144 0.332
IR accepted: Θ = Θccr(2) 3962 −0.140 0.400
Channel Noise (NEDT) 0.242
number
Θ − Θtru
300
250
200
150
100
50
0
−6
−4
−2
0
2
4
6



Cloud Cleared Radiance Error Distribution at f=937.81
bin size =0.050
For "Granule 401": 7200 cases
mean sdv
clear: Θ = Θccr(2) 432 −0.158 0.298
near clear: Θ = Θccr(2) 970 −0.284 0.507
easy cloud: Θ = Θccr(2) 2614 −0.339 0.776
IR accepted: Θ = Θccr(2) 3962 −0.394 0.902
Channel Noise (NEDT) 0.064
number
Θ − Θtru
300
250
200
150
100
50
0
−6
−4
−2
0
2
4
6


LAYER MEAN RMS TEMPERATURE ERRORS (°C)
All Accepted Cases (55.0%)
Easy Cases (36.3%)
Nearly Clear Cases (13.5%)
Clear Cases (6%)
PRESSURE (mb)
1
5
20
50
100
200
400
600
800
1071
0
0.5
1
1.5
2
RMS ERROR
TEMPERATURE RMS ERRORS
SKIN TEMP
STATISTICS
trop
700-surf
0.81 0.92 1.04 All Accepted Cases
0.68 0.85 0.97 Easy Cases
0.51 0.75 0.84 Nearly Clear Cases
0.51 0.70 0.74 Clear Cases


1 Km LAYER PRECIPITABLE WATER PERCENT ERRORS
All Accepted Cases (55.0%)
Easy Cases (36.3%)
Nearly Clear Cases (13.5%)
Clear Cases (6%)
PRESSURE (mb)
200
400
600
800
1071
0
5
10
15
20
25
30
35
40
RMS ERROR
WATER RMS ERRORS
Total 1 Km LAYER
% %
3.9 15.7
3.5 17.0
3.7 17.9
1.6 16.9
All Accepted Cases
Easy Cases
Nearly Clear Cases
Clear Cases

SUMMARY

RECONSTRUCTED CLEAR COLUMN RADIANCES SHOULD BE USEFUL FOR DATA ASSIMILATION

- RADIANCE ERRORS ARE COMPARABLE TO SINGLE SPOT NOISE
  - FOR SOME TEMPERATURE SOUNDING CHANNELS UNDER ALL CLOUD CONDITIONS
  - FOR MOST TEMPERATURE SOUNDING CHANNELS UNDER MOST CLOUD CONDITIONS

TEMPERATURE SOUNDINGS ARE ACCURATE UNDER ALL CONDITIONS

- DEGRADE SLIGHTLY IN TROPOSPHERE WITH INCREASING CLOUD COVER, CLOUD COMPLEXITY

WATER VAPOR SOUNDINGS DO NOT DEGRADE WITH INCREASING CLOUD COVER